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MINIROTATION FORESTRY

By

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MINIROTATION FORESTRY[1]

By Ernst J. Schreiner[2]

It has been said that there is nothing new under the sun; and originality has been defined as the art of remembering what you hear and forgetting where you heard it. This paper is an attempt to utilize ideas, predictions, estimates, and facts from many sources to chart a possible avenue of approach for future production of fiber and timber in the Northeastern Region.

I am not an economist and will not attempt to predict forestry's future economic environment. It has been said that, if all the economists in the world were laid end to end, they would still point in all directions; I will quote briefly four economists who are pointing in my desired direction.

Under the title, "Forestry's Changing Economic Environment," Fedkiw (1970) notes that, "Forestry will have to go all out for genetically superior trees, fertilization, stocking and brush control, sycamore silage, highly intensified utilization, and other new technologies." And that, "There has never been a greater need for enlightened leadership and exploding innovations in forestry practice."

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[1] Invited paper presented at the Spring Meeting of the Northeastern Technical Division of A.P.A., Gorham, N. H., May 26, 1970.

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FOREST LAND AND WOODS LABOR

According to Wheeler (1960), the report of the Southern Resource Analysis Committee, titled "The South's Third Forest," includes an estimate that some 10 million acres of forest land in the South will be withdrawn for agriculture, urban expansion, rights-of-way, reservoirs, recreation, and other uses by the end of the century.

Drysdale (1969) hazards a guess that, by the year 2010, Canada will be retiring about one-third of the most expensive and least productive forest sites from the production of commercial wood products to concentrate major wood-production efforts on forest lands with the best combination of productive capacity, accessibility, and proximity to markets.

How much forest land will be available for profitable timber production in the Northeastern Region by the end of this century?

The key to continued and increased production of wood and fiber in the Northeast may well be the private landowners; their lands are usually the most accessible and most productive areas available for intensive forest culture. Fields (1969) reports that a recent survey conducted by the Tennessee Valley Authority in the seven Valley States indicated that approximately 139 thousand acres of private forests were already under long-term lease with a forest industry or some other second party. More important, owners of almost 4 million acres said they might be interested in such an arrangement.

Swan (1969) has presented the dim picture of the availability of woods labor in the Northeast at the present time; there is no reason to expect that it will improve in the future. He notes that young men can be recruited and trained to operate logging equipment, and under logging equipment I assume he includes only heavy equipment, not the chain saw. How much chain-saw labor will be available for the harvesting of fiber and timber in 1980? And, how much will it cost?

Drysdale (1969) has suggested that in Canada during the next 40 years there will be a gradual switch from a single-tree harvesting system, in which the size of the individual tree is economically important, to a multi-tree system which depends more on the total volume per acre and provides an opportunity to take advantage of shorter rotation periods. We will not have as much as 40 years to effect such a change in our Northeastern Region.

THE NEED FOR INTENSIVE SHORT-ROTATION FORESTRY

The probability of a shortage of softwoods in the Northeast for fiber and lumber is generally admitted. Although we are already aware of a serious shortage of quality logs for the hardwood lumber industry, it appears to be the general opinion that there will be no shortage of hardwood for conversion to fiber. Can we count on this? The hardwood will be here 10 or 20 years from now, but it is highly probable that a combination of the lack or high cost of chain-saw labor to harvest forest crops on the steep terrain in this region, and public pressure against clear-cutting of the lowland forest areas visable from practically all of our highways, will result in a short and expensive supply of hardwood fiber.

We are now harvesting our fourth, practically unmanaged, forest. The first forest was harvested with the axe and oxen; the second with the two-man saw, horses, and narrow-gauge railroads; the third with the buck saw, horses and tractors; and the fourth is now being managed and harvested with the chain saw and tractors. The Fifth Forest of the Northeast will have to be managed intensively and established, cultured, and harvested by machine.

Tables 1 and 2 are sufficient to indicate, very briefly, the length of rotations in our Fourth Northeastern Forest under present management recommendations for present utilization requirements.

Table 1 gives estimates of the years to reach a given mean diameter, for managed (thinned) stands of mixed northern hardwoods. Estimates for a mean stand diameter of 5 inches are 33 years (site 70) to 44 years (site 50); 9-inch mean stand diameter in 62 years (site 70) to 93 years (site 50); and 15-inch mean stand diameter in 118 years on site 70.

Table 1. -- Years to reach a given mean diameter by site index for managed (thinned) stands of mixed northern hardwoods.[1]

Mean d.b.h.	Site index		
	70	60	50
Inches	Years	Years	Years
5.0	33	38	44
9.0	62	77	93
15.0	118	--	--

[1] Excerpt from William B. Leak, et al. (1969, p. 20).

Table 2 lists the expected rotation ages and sizes for two site qualities for paper birch boltwood and sawtimber, other hardwoods for sawtimber, spruce-fir pulpwood, and spruce sawtimber. The expected rotations for paper birch are boltwood with an average stand diameter of 9 inches at 45 years on site 70, and an 8-inch average stand diameter on site 50 in 65 years; sawtimber on site 70 in 65 years, on site 50 in 75 years. The rotation age in managed stands for hardwood sawtimber of other species has been estimated as 120 years for site 70, 135 years for site 50. For spruce-fir pulpwood the estimated rotation for average 9-inch diameter wood is 65 years for site 70 and 75 years for 8-inch average stand diameter on site 50. For spruce sawtimber, the rotation ages are estimated at 120 years for site 70 and 135 years for site 60.

THE POSSIBILITIES FOR INTENSIVE SHORT-ROTATION FORESTRY

I predict that by 1980 our present long-rotation, chain-saw forestry will have begun to give way to intensive short-rotation forestry; and this could be started on our best sites with densely stocked, young stands.

Although we do not have the large expanses of flat or rolling forest land most suitable for the use of heavy machinery, our climate and most of our soils are conducive to maximum wood production under intensive culture with the elimination of practically all hand labor. Heavy equipment is already available for intensive silviculture; including site preparation, planting, cultivation, thinning, and harvesting.

Table 2. -- Expected rotation ages and sizes for stands under management.[1]

Species and objective	Paper birch site index (height at b.h. age 50)	Average diameter[2]	Age
	Feet	Inches	Years
Paper birch, boltwood	70	9	45
	50	8	65
Paper birch, sawtimber	70	11	65
	50	9	75
Other hardwoods, sawtimber	70	15	120
	50	11	135
Spruce-fir, pulpwood	70	9	65
	50	8	75
Spruce only, sawtimber	70	14	120
	60	13	135

[1] Excerpt from David A. Marquis, et al. (1969, p. 40).

[2] Average diameter of the species shown -- not of the entire stand.

Hayes (1970) has reported the cost range for site preparation, including clearing, debris treatment, soil preparation, and planting, as from $25 to $45 per acre. He concludes that, "A new technological breakthrough is long overdue. We have tried to beat trees to death, poison them, chew them up, and drive them into the ground; but we usually revert to overpowering them."

The economical establishment of densely stocked conifers and hardwoods that cannot now be propagated from cuttings will require direct seeding. A furrow-seeder is available that can direct-seed an acre of white or red pine, in furrows spaced 12 feet apart, in approximately 15 minutes on an open field with 0 - 8 percent slope; and in approximately 32 minutes on a brushy hillside with 10 - 20 percent slope (Graber and Thompson, 1969).

An efficient machine for planting dormant hardwood cuttings has been developed and used in the nursery at Indian Head, Saskatchewan. A 4-row machine can plant 30,000 cuttings per hour with a crew of ten. This includes the labor for transporting the cuttings to the field and replenishing the cutting boxes on the planter (Cram, 1969).

A mechanized harvesting-thinning machine has been designed to mechanically harvest under-sized timber in overstocked natural stands and in plantations. The smaller timber could not be harvested manually because of excessive cost, but this new machine is said to be turning this operation into a profit-maker (Anon. 1968).

Machine thinning will require mechanical (line or row) thinning rather than selective silvicultural thinning. Shortage of labor for forest management in Poland has led to attempts at machine thinnings. Bernadzki (1969) has reported that line thinning, when compared with selection thinning, has resulted in reduction in the number of the most valuable trees and has decreased the possibility for selection of plus trees. However, the negative impact of this thinning is more strongly marked in stands of poor quality than in stands of high quality growing at dense spacing.

MINIROTATION FORESTRY - THE FIFTH FOREST OF THE NORTHEAST

According to Wheeler (1960), "Even now the Third Forest of the South is beginning to materialize. Over 15 million acres -- an area about the combined size of New Hampshire, Connecticut, Delaware, and Maryland -- have been planted in pines."

How soon can we start to obtain the practical "know-how" needed to establish our Fifth Forest of the Northeast for Minirotation Forestry on the more productive and accessible lands, and in young, fully stocked natural stands that are available for fiber and timber production? We should have started at least 20 years ago. The eventually irresistable pressure of public opinion and limited land and woods labor will become effective much sooner than the selection and creation of genetically superior fast-growing trees and the development of establishment and cultural methods needed for maximum forest production on minirotations.

I am suggesting the term "minirotation forestry" to include the production of fiber, on rotations of one to four or five years (minirotation fiber production)[1], boltwood for fiber, particle board or other uses on rotations of 6 to 15 years (minirotation boltwood production), and lumber and veneer logs on rotations of 15 to 30 years (minirotation timber production). Depending on the species and the product, minirotations (like miniskirts) may be of various lengths, but always short for the particular objective.

One or several species, varieties, or hybrids may be grown in mixture for a single, for two, or for all three minirotations (fiber-, bolt-, or timber-minirotations).

Minirotation forestry will require: (1) machine site preparation, planting, cultivation, and harvesting; (2) intensive culture including fertilization on good sites; (3) rapid-growing superior varieties or hybrids; (4) utilization of small stem-wood, and if possible, branch wood.

The advantages of minirotation forestry will be: (1) early amortization of the cost of site preparation, planting, and early culture; (2) very much smaller land areas for the production of large quantities of fiber or timber; (3) profitable use of the most highly productive and economically manageable lands; (4) smaller and cleaner clear-cut areas that are less likely to be objectionable to the general public.

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[1] The utilization of juvenile growth of sycamore for fiber has been called "Silage" sycamore by McAlpine, et al. (1966).

Minirotation forestry must be based on even-aged culture. I am fully aware of the possible public objection to clear-cutting, but there never has been any public outcry against the use of large open areas for extensive pasture or agricultural crop production. The main reason for public objection to clear-cutting of forest stands may be the extent of such areas and the scraggly appearance of the nonmerchantable residual trees and the large amount of slash and debris left after logging which aesthetically can be as objectionable as a junk automobile yard. The utilization of the best productive timber sites for minirotation forestry will minimize the area of clear-cutting; the less productive parts of forest properties should be left in long-rotation management. The need for intensive culture to maximize wood production on minirotations will profit most from complete disposal of slash by chipping all such material, either for commercial utilization or to provide a mulch that can be worked into the soil in fitting the land for the succeeding crop. With such utilization, site preparation at the end of the longest minirotation would leave the land with the same appearance as well-kept farm land.

Maximum production of usable material under minirotation management will require complete utilization of the site. This will necessitate close planting (the spacing depending on the species or variety and on the length of the longest and/or shortest rotation objective), with frequent thinnings to maintain the growth rate of the remaining stand. Each required thinning must provide a merchantable yield of fiber or boltwood.

Much of the land required for minirotation forestry would presently be classified as farmland, either actively farmed or abandoned. There is every indication that the availability of such land for forestry will increase in future years; extensive farming will be profitable on only a relatively small proportion of the land area in the Northeast. Considerable abandoned farm land in private ownership would probably be available for lease by wood-using industries interested in minirotation management. The owners themselves would not be in a position to manage for wood production, but either wood-using industries or forest production companies with sufficient equipment could manage many of these smaller properties for minirotation production.

SPECIES AND HYBRIDS FOR MINIROTATION TRIALS

The following species and hybrids could be used for immediate, small-scale trials of minirotation management in the Northeast.

Hardwoods.

Poplar (*Populus*) hybrids

Eastern cottonwood (*Populus deltoides* Bartr.)

Silver maple (*Acer saccharinum* L.)

Quaking aspen (*Populus tremuloides* Michx.)

Bigtooth aspen (*Populus grandidentata* Michx.)

American sycamore (*Platanus occidentalis* L.)

White birch (*Betula papyrifera* Marsh.)

Yellow birch (*Betula alleghaniensis* Britton)

Northern red oak (*Quercus rubra* L.)

Black cherry (*Prunus serotina* Ehrh.)

Black willow (*Salix nigra* Marsh.)

Red maple (*Acer rubrum* L.)

European black alder [*Alnus glutinosa* (l.) Gaertn.]

Pin cherry (*Prunus pensylvanica* L.)

Gray birch (*Betula populifolia* Marsh.)

Tree of heaven [*Ailanthus altissima* (Mill.) Swingle]

Conifers.

Eastern white pine (*Pinus strobus* L.)

Hybrid larch (*Larix xeurolepis* Henry)

Japanese larch (*Larix leptolepis* Sieb. & Zucc.)

Norway spruce [*Picea abies* (L.) Karst.]

White spruce [*Picea glauca* (Moench) Voss]

Scotch pine (*Pinus sylvestris* L.)

Red pine (*Pinus resinosa* Ait.)

Some of the species listed above will be suitable for only minirotation fiber production (e.g., gray birch, pin cherry), others may be used for all three minirotations (e.g., hybrid poplars, cottonwood, sycamore, white pine, larch). Nonsprouting species, such as the conifers, would require replanting after each harvest cutting. The possibilities of only a few of these species will be very briefly indicated in this short paper. The hybrid poplars will be used to present a prototype for minirotation management.

Eastern cottonwood. Superior genotypes of this species will grow as rapidly on the most fertile bottomland sites in the Northeast as cottonwoods on the highly fertile soils of the batture lands of the Mississippi (figures 1 and 2).

Figure 1. D.b.h. section from a native eastern cottonwood growing on a bottomland site near Albany, N. Y. This 6-year-old tree was 6.75 inches in d.b.h. (i.b.).

Figure 2. D.b.h. section from a 16-year-old eastern cottonwood from a bottomland site in the vicinity of Albany, N.Y.; d.b.h.(i.b.) 16.5 inches.

Yellow birch. The growth possibilities of yellow birch are indicated in figure 3.

Figure 3. ellow bi ch; section 18 inches above the ground from a tr e cut near erlin, N. H.; 16 in ches (i.b.). The total age is 90 year , but the t ee was ob viously su pressed during the first 60 years. In the last 30 y ars the tree has grown at a rate that indicates excellent possib lities f r selecti n of genetically rapid-growing trees for intensive mi irotation timber culture.

Silver maple. Mr. H. C. Larsson, of the Ontario Department of Lands and Forests, has been selecting plus trees of this species. Figures 4 and 5 show plus tree selections in a stand that originated after clear cutting in 1926 (apparently largely from sprout reproduction). Note the gross volume available after approximately 36 years.

Figure 4. Silver maple selection B-3-6; d.b.h. 12.2 inches; total height 90 feet; stand age approximately 36 years. (Ontario Dept. of Lands and Forests Photo.)

Figure 5. Silver maple selection B-3-4; d.b.h. 11.0 inches; total height 75 feet; approximate stand age 36 years. (Ontario Dept. of Lands and Forests Photo.)

Hybrid larch. The case for hybrid larch has been presented by Perry and Cook (1965), and by Cook (1969). Figures 6 and 7 illustrate the growth in Cooxrox Forest, Stephentown, N. Y.

Figure 6. The "Giant in number 19," probably an F_3 hybrid. This stand was planted with 2-0 seedlings in November 1935. The photograph was taken after 30 growing seasons when the Giant was 14.4 inches d.b.h. and 76 feet tall. (D. B. Cook Photo.)

Figure 7. The "Giant in number 7;" planted as a 2-0 seedling in a single-tree failed spot in a red pine plantation that was established in 1931. After 30 growing seasons, this larch, although five years younger than the red pines, was 16.0 inches in diameter and 75 feet in total height, considerably taller than even the best of the red pines. (D. B. Cook Photo.)

Eastern white pine. The excellent possibilities for minirotation management of eastern white pine are apparent in the reported yields of plantations in Pennsylvania (table 3). The first profitable cuttings on the basis of present pulpwood specifications would probably be at 20 years on site index 90 with a merchantable volume of 8.5 cords, and on site index 70 at 25 years with 10.4 cords.

With utilization of the total volume (small-diameter stem-wood) site index 70 would yield 12 cords at 15 years, 23.4 cords at 20 years, and 35.9 cords at 25 years. Site index 90 would yield 14.8 cords at 15 years, 31 cords at 20 years, and 48 cords at 25 years. I believe that all of these figures are minimums, that they could be increased by at least 50%, and the earliest yields probably doubled, by the use of inherently rapid-growing trees, closer spacing, adequate site preparation, fertilization, and early cultivation on the better sites available in the Northeastern Region.

Figure 8. A section of eastern white pine, cut one foot above the ground, to illustrate early growth without plantation culture; age 13 years, diameter 6.5 inches (i.b.).

Table 3. -- Eastern white pine. Empirical yield table, 4 x 4-foot plantations -- Pennsylvania.[1]

Stand age from planting	50-Year Site Index: 70					50-Year Site Index: 90				
	No.[2] of trees	Avg. d.b.h.	Volume			No.[2] of trees	Avg. d.b.h.	Volume		
			Total	Merchantable	Total			Total	Merchantable	Total
Years	No.	Inches	Cu.ft.[3]	Cords[4]	Cords[5]	No.	Inches	Cu.ft.[3]	Cords[4]	Cords[5]
15	1,386	3.3	1,076	0.2	12.0	1,098	4.2	1,332	1.9	14.8
20	1,543	4.2	2,110	3.6	23.4	1,156	5.1	2,787	8.5	31.0
25	1,324	5.0	3,231	10.4	35.9	992	6.0	4,322	19.5	48.0
30	1,104	5.7	4,399	19.5	48.9	793	6.9	5,890	33.5	65.4
35	900	6.4	5,553	30.0	61.7	624	7.9	7,435	50.6	82.6
40	729	7.2	6,655	40.1	73.9	474	9.2	8,894	64.1	98.8
45	594	8.0	7,654	48.6	85.0	349	10.7	10,236	74.5	113.7
50	489	8.8	8,505	56.0	94.5	262	12.3	11,375	83.4	126.4
55	412	9.6	9,224	62.7	102.5	203	14.1	12,327	91.3	137.0

[1] Excerpt from Marty (1965, pp. 53, 54). Source data: Delong, Thomas S. (1955).

[2] All trees 1.0 inch + d.b.h.

[3] Total cubic-foot volume including stump, stem, bark, but not limbwood.

[4] Rough cords to a variable top of not less than 4.0 inches i.b., and a 1-foot stump.

[5] Total cu. ft. volume converted, for this paper, on the basis of 90 cu. ft. per cord.

White spruce. The growth possibilities of this species are shown in figures 9 and 10.

Figure 9. A cross section 20 inches in diameter (i.b.) taken at 1-foot stump height. This tree, from Colebrook, N. H., was 43 years old at the stump, 17 inches in d.b.h. (o.b.), and 58 feet in total height.

Figure 10. Cross section, 24 inches above the ground, of a pedigreed white spruce seedling planted in sod at Williamstown, Massachusetts. The tree was 13 years old from seed, diameter of this section 4.75 inches (i.b.). Note the rapid growth from the ninth to the thirteenth year. Early cultivation and fertilization would have greatly increased the growth rate during the first nine years.

Norway spruce. This species has been planted in the Northeastern Region since Colonial days. It usually outgrows white spruce in its early years. Hughes (1970) has reported that the mean annual net increment of a 51-year-old stand in Nova Scotia was 144 cu. ft. per acre, and that this level of production (1.7 cords per acre per year) is almost twice the peak increment shown for site quality 1 in Nova Scotia. Figure 11 indicates the possibilities for rapid juvenile growth of this species.

Figure 11. Norway spruce. Cross section taken two feet above the ground, 5.5 inches in diameter (i.b.). The tree, 14 years old from seed, was planted in sod without cultivation at Williamstown, Massachusetts. Note the improved growth from the ninth to the fourteenth year; selection for rapid inherent growth, site preparation, and cultivation undoubtedly would have doubled the earlier growth rate.

Scotch pine. Pedigreed seedlings have grown 9 inches or more in d.b.h. (i.b.) in 15 years from seed without site preparation or cultivation at Williamstown, Massachusetts (see figure 12).

Figure 12. Scotch pine. Section taken 2 feet above the ground of a Scotch pine 15 years from seed without site preparation or cultivation at Williamstown, Massachusetts; diameter (i.b.) 9.5 inches.

Red pine. The possibilities for rapid early growth is apparent in figure 13. Intensive culture of this plantation in Alfred, Maine, would have increased early growth and maintained the growth rate through the last 5 years.

Figure 13. Red pine plantation tree, Alfred, Maine. Section cut one foot above the ground; age 19 years, diameter 10.2 inches (i.b.).

Hybrid poplars. Some 250 of the more than 13,000 hybrid poplars produced in 1925 and 1926 by the Cooperative Oxford Paper Company -- New York Botanical Garden Hybridization Project (Stout and Schreiner, 1933; Schreiner, 1937) have been selected and tested by the Northeastern Forest Experiment Station for their performance on upland sites in the Northeast. The growth potential of some of the best hybrids is apparent in figures 14 to 18.

Figures 14 and 15 show one of the hybrids, NE-200 (*P. deltoides* x *P. trichocarpa*) that was selected in the original Oxford Paper Company plantation, Frye, Maine, for clonal tests and cut for pulping tests. These original hybrid seedlings were planted at 6 x 6-foot spacing and were never thinned. Figure 15 is a photo of the merchantable pulpwood from this tree.

Figure 14. Poplar hybrid NE-200 (*P. deltoides* x *P. trichocarpa*) selected for clonal and pulping tests; age 18 years, d.b.h. 11.5 inches, total height 60 feet.

Figure 15. Poplar hybrid NE-200. Merchantable pulpwood cut from tree in figure 14.

The difference in growth of the same hybrid clone, the Androscoggin poplar (Schreiner and Stout, 1934), in the open and at 6 x 6-foot plantation spacing is shown in figures 16 and 17. The open-grown tree in Philadelphia (figure 16) was 30 inches in d.b.h. and 80 feet tall at 16 years. The ramets of this clone in the 6 x 6 plantation near Frye, Maine, (figure 17) averaged 8 inches in d.b.h. and approximately 60 feet in total height at 15 years. But, the total cubic volume per acre was practically the same for the 6 x 6-foot plantation as for the open-grown individual at an estimated spacing of 25 x 25 feet.

Figure 16. Hybrid poplar. An open-grown specimen of the Androscoggin poplar growing on fertile bottomland soil in Philadelphia. At 16 years this tree was 30 inches in d.b.h. (o.b.) and 80 feet tall. This same hybrid clone was planted at 6 x 6-foot spacing near Frye, Maine (figure 17).

Figure 17. Hybrid poplar. Ramets of the Androscoggin poplar planted in a 6 x 6-foot plantation on fertile bottomland near Frye, Maine. The trees were 15 years old, their average d.b.h. was 8 inches, and their average total height, 60 feet (see also figure 16).

Figure 18. Hybrid poplar. This is a section (18 inches above the ground) from a 20-year-old tree in a test plantation established with dormant cuttings at 4 x 4-foot spacing, on a plowed and harrowed upland site at Williamstown, Massachusetts. The test plantation was cultivated during the first year only, and thinned lightly as needed.

Figure 19. Hybrid poplar clone NE-264 (P. cv. Angulata x P. cv. Volga) in a clonal test on an upland site in Williamstown, Massachusetts. This photo was taken when the trees were 20 years old. Fifteen-year average height was 61 feet, with maximum height 76 feet. (Photo by John Kendig.)

MINIROTATION HYBRID POPLAR FIBER PRODUCTION

In the spring of 1935, four-year-old nursery stock of 15 hybrid poplar clones in the Oxford Paper Company's nursery near Frye, Maine, were cut back to the ground to produce cutting stock for use in the spring of 1936. These hybrids had been grown from unrooted cuttings at one-foot spacing in rows spaced 4 feet apart. Since this was an opportunity to determine the production of fiber on a short rotation, I stored the four-year-old stems for dry-weight determination and possible pulping trials. The length of the row from which each lot of stems was taken and the percent survival in the row were recorded when the hybrids were cut.

Survival within the hybrid clones varied from 70 percent to more than 95 percent. Observations on the various hybrids indicated that the growth of trees spaced 1 foot apart (100% survival) was fully as good as the growth in more sparsely populated portions of the same clones. Therefore, for comparison of the hybrids, the yield per acre of peeled stems was calculated on the basis of 95 percent survival.

The oven-dry weight of the branches with bark, and of the oven-dry weight of peeled stems exclusive of the leader (the fourth-year leader was not included) was determined in August 1935. The calculated yields per acre of side branches with bark, of peeled stem-wood and the equivalent in cords of peeled stem-wood are given in table 4. The range in oven-dry weight of the peeled stem-wood of these 15 clones varied from 17,240 lbs. (8.2 cords per acre) to 4,680 lbs. (2.2 cords per acre). An examination of the growth rings indicated that the optimum rotation for this spacing and this site in western Maine would be three rather than four years. Diameter growth was maintained during the third year, but it dropped very considerably during the fourth year.

These early results in Maine indicated the possibilities of very short rotations for the production of poplar fiber, but, unfortunately, this 1935 research was at least 35 years ahead of its time. The pulp and paper management agreed:

(1) that the production of fiber from fast-growing hybrid poplars on a two- to three-year rotation offered excellent possibilities from the standpoint of the amount of fiber produced per acre;

(2) that a machine to economically harvest such small stems could be developed;

(3) that once the stand was planted it would reproduce from sprouts after each fiber harvest; and

(4) cultivation to control weeds would be necessary only once or twice in the first year after each harvest.

Table 4. -- Yields of fifteen 4-year-old hybrid poplar clones at 1 x 4-foot spacing.

Oxford Paper Company Nursery, Frye, Maine, 1935

Hybrid No.	Oven-dry yield estimated on basis of 95 percent survival		
	Branches with bark	Peeled stem wood [1]	
	Lbs./acre	Lbs./acre	Cords/acre [2]
NE-44	5,920	17,240	8.2
-41	5,480	15,320	7.3
-49	2,440	14,300	6.8
-4	5,340	13,800	6.6
-50	4,460	13,560	6.5
-39	6,800	13,560	6.5
-46	6,320	13,480	6.4
-28	5,400	13,240	6.3
-29	4,560	11,680	5.6
-45	4,280	10,980	5.2
-32	3,600	10,900	5.2
-21	3,300	10,820	5.2
-54	5,200	8,100	3.9
-9	5,440	7,760	3.7
-26	1,760	4,680	2.2

[1] Oven-dry weight of peeled 3-year stems -- the fourth-year leader was not included.

[2] Based on 2100 lbs. per cord; the reported oven-dry weight of aspen.

But there was one, at that time, insurmountable obstacle to such short-rotation fiber production -- the separation of the bark from the chips or pulp. And, for the paper maker, this problem is still with us. Fortunately, there now is sufficient interest in separating bark from chips to predict practical methods will be developed within the next decade.

Erickson (1970) has posed two questions that may bear on this problem within the next 10 years: "Will the technology in pulping change so that more bark will be allowed? Will it be feasible in the future to remove most of the bark during the pulping process?"

Present research on separation of bark after chipping has involved the bark of larger trees. I suggest that the young bark of one-, two-, or three-year-old stems and branches may not be as troublesome as the mature bark of older trees; that it might be an "allowable" constituent of the pulp if we can persuade the pulp and paper researchers to seriously, and strenuously, attack this problem.

The utilization of such young wood may also involve shorter fiber. However, there is evidence that genetic selection for reasonably long-fibered young growth is possible. It is also reasonable to suggest that for many uses, even in paper stock, short fibers will prove suitable. This should apply, for example, to the use of short-fibered hardwoods for opacity and printability of high-grade papers.

Bowersox and Ward are investigating the juvenile growth and yield in Pennsylvania of the Northeastern Station's hybrid poplar clone NE-388 (P. maximowiczii x P. trichocarpa). The yields per acre at 3 different spacings are reported in table 5, and illustrated in figures 20 and 21. The rate of increase (table 5) indicates that this hybrid will equal or surpass the 4-year yield of clone NE-44 in the 1935 tests in Maine.

Figure 20. Hybrid poplar NE-388 (P. maximowiczii x P. trichocarpa). Three-year-old stand from dormant cuttings. (Pa. State U. Agr. Expt. Sta. Photo.)

Figure 21. Hybrid poplar NE-388 (P. maximowiczii x P. trichocarpa). Interior of the 2 x 2-foot, 3-year-old planting. (Pa. State U. Agr. Expt. Sta. Photo.)

A final word on the possibilities of minirotation of hybrid poplar for fiber production. The yields in Maine and those in Pennsylvania were based on 4- and 3-year-old trees from unrooted cuttings; the plants had not been cut back to the ground (stooled).

The 4-year-old clones in the Maine trials ranged from 8 to 18 feet in average height. If these hybrids had been stooled, they would have grown to the same heights in not more than two years. Stooled hybrids have grown to average heights of 10 to 14 feet in one year in nursery plantings in Philadelphia (figure 22).

Figure 22. Hybrid poplar nursery stools at 1 x 4-foot spacing, Philadelphia, Pa. One-year growth on 3-year-old stools that had been cut back annually for the production of cuttings.

Table 5. -- Yields of oven-dry, peeled stemwood. Hybrid poplar clone NE-388.

State College, Pennsylvania

Spacing	1-year-old [1] trees		2-year-old [1] trees		3-year-old [2] trees	
Feet	Lbs./acre	Cds/acre[3]	Lbs./acre	Cds/acre[3]	Lbs./acre	Cds/acre[3]
½ x 2	1024	0.5	3816	1.8	11,940	5.7
1 x 2	658	0.3	3101	1.5	10,006	4.8
2 x 2	455	0.2	1923	0.9	7,616	3.6

[1] Excerpt from Bowersox and Ward (1968).

[2] Todd W. Bowersox, personal communication.

[3] Converted for this paper on the basis of 2,100 lbs. per cord; the reported oven-dry weight of aspen.

MINIROTATION HYBRID POPLAR BOLTWOOD AND TIMBER PRODUCTION

Hybrid poplars planted at 6 x 6-foot spacing on good upland sites would yield 10 cords per acre of boltwood from thinnings between the 8th and 10th years, and a final harvest of 30 cords per acre at 15 years (Schreiner, 1949). With 4 x 4-foot spacing, two thinnings (one at 5 to 8 years and a second at 12 to 15 years) would produce considerable additional boltwood and leave about 170 trees per acre spaced 16 x 16 feet for a final cordwood or timber and veneer wood harvest between the 20th and the 25th years.

MINIROTATION FIBER, BOLTWOOD, AND TIMBER PRODUCTION WITH A SINGLE SPECIES OR WITH TWO OR THREE SPECIES

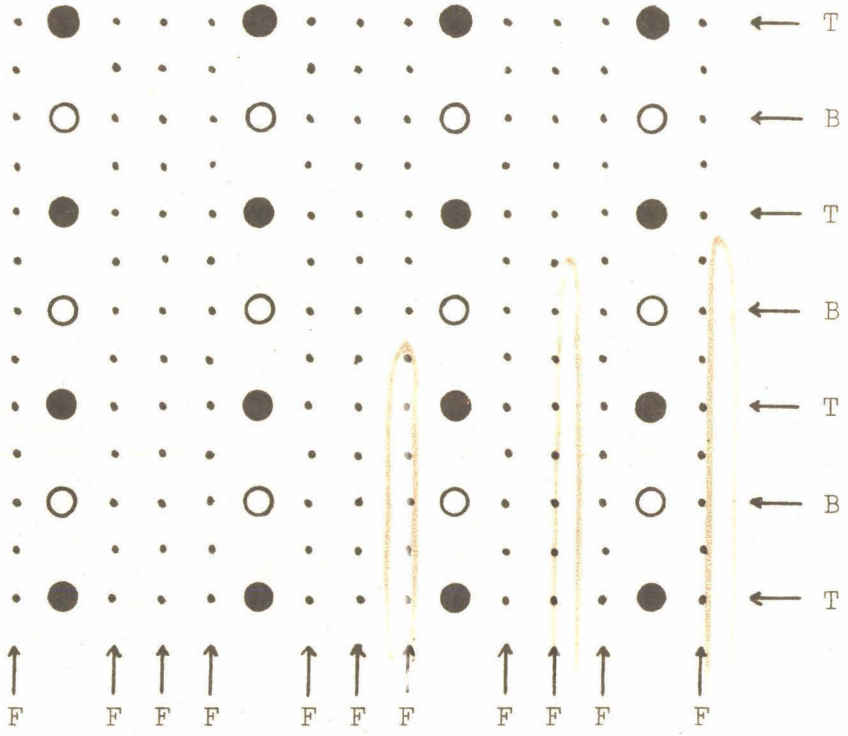
Figure 23 is a generalized lay-out without designation of species or spacings. This could be for a single species, but for nonsprouting species, such as conifers, there would be only one fiber harvest; it would not pay to reseed the fiber (F) rows. For a sprout-species, the fiber harvests could be repeated at the most profitable intervals.

A combination of species would be preferable, for example, hybrid poplar for fiber (F) with white pine for boltwood (B) and timber (T); or with larch for the boltwood (B) and white pine for the timber (T) minirotations.

Recommendations on choice of species, species mixtures, and spacing must await the results of small-scale applied research; I sincerely hope such applied research will be started in the near future.

In closing, I will again quote Fedkiw, "There has never been a greater need for enlightened leadership and exploding innovations in forest practice."

Figure 23. -- Generalized lay-out for minirotation fiber, boltwood, and timber production.



F = Fiber production

B = Boltwood production

T = Timber production

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